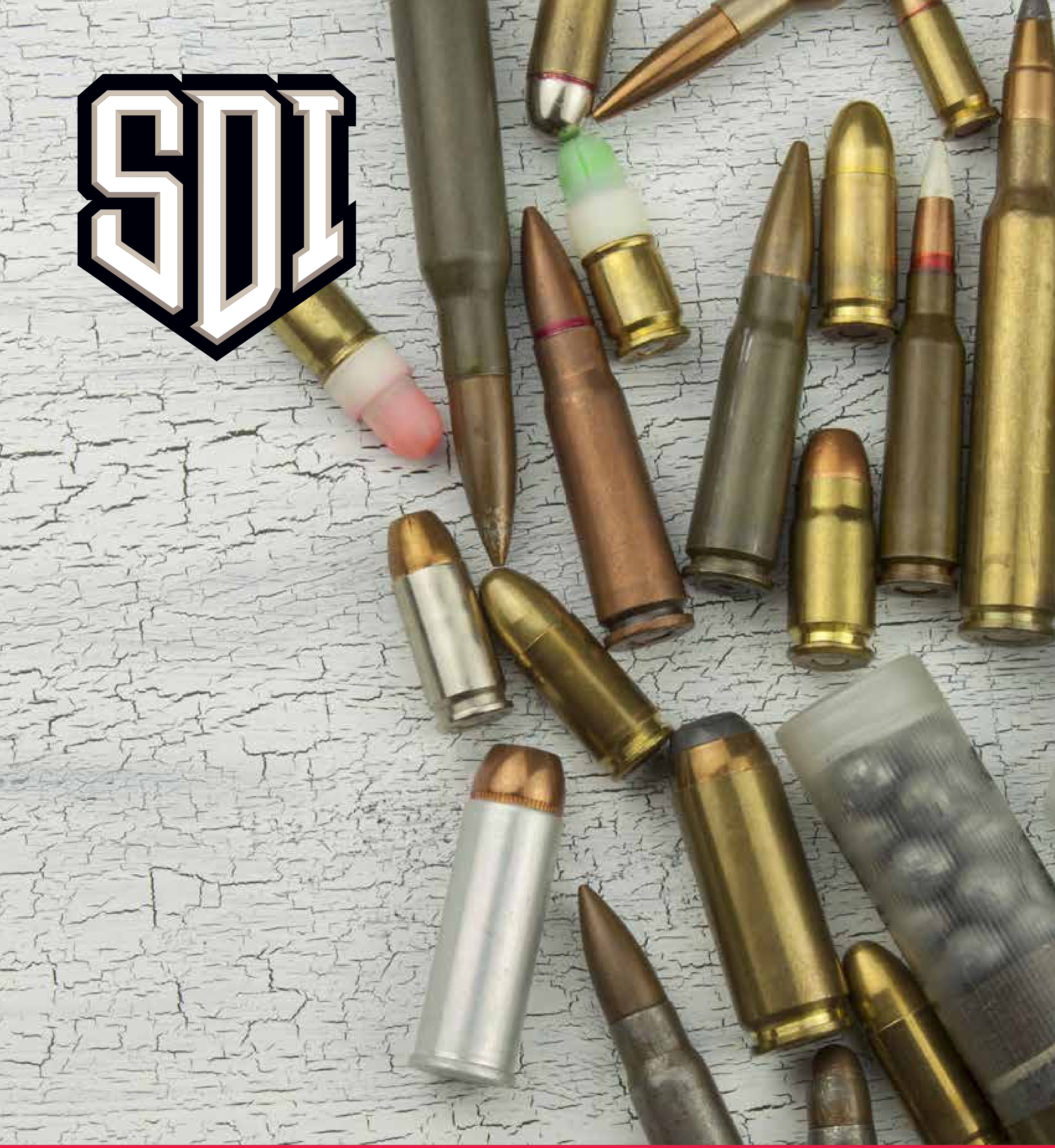

SDI Guide to Projectiles

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A Brief History

For millennia, there has been some form of projectile used for hunting, self-defense, war, and even sport. The projectile may even be the single greatest contributor to the development of weapons ever. The first projectile was almost certainly a stone. Throwing rocks eventually led to the creation of the sling and sling shot. Early man would also sharpen sticks or bones affixed to long sticks, creating the first spears. Once it was discovered that some stones could be shaped and sharpened, they began affixing them to the ends of sticks, which led to the first arrows. Eventually, humans learned how to refine metal, and those rocks and stone spear heads were replaced in favor of lead, copper, brass, bronze, iron, and, eventually, steel projectiles.

The invention of black powder accelerated the evolution of the projectile more than any other contributing factor. The first "firearms" and cannons propelled whatever could be shoved down their muzzles, including rocks, cast metal balls, and other scrap that would fit. The first metal projectiles were round(ish), typically steel or brass/bronze, and a smaller diameter than the (smooth) bore. The projectiles would just roll down the barrel and rest atop the powder charge. Eventually, paper or cloth wadding, or patches, were used to provide a tighter seal of the ball to the barrel and secure it from falling out. Soon after, the patch was replaced by a lead ball that was slightly larger than the bore and required the operator to ram it down the barrel.

Figure 1: Various Minié balls.

It wasn't until the beginning of the 19th century that we began to see what would be considered a "modern" bullet design. Around 1830, we begin to see the first cylindrical-conical bullets. The early bullets featured a cylindrical body and semi-pointed nose. Around the same time, we also began to see the first breechloaders and rifled barrels. These advancements in technology were a huge improvement over the round ball and smoothbore in both range and accuracy. Between 1830 and 1845, several new bullet designs were introduced that featured hollow bases and some means of forcing the base to expand. The expanding base would seal the bullet in the bore and form to the barrel's rifling. Almost all of these designs were abandoned for various reasons, including complications of manufacturing and complacency with old technology.

It wasn't until 1847 that a French army captain named Claude Etienne Minié created a soft lead, hollow base, conical bullet known as the Minié ball. The Minié ball featured an iron plug in the base of the bullet that upon firing would wedge itself into the base and force the body to expand and seal the bullet against the bore and rifling. The Minié ball was adopted by the British government in 1855 for use in the Enfield rifle. From around 1855 to early 1880, the Minié ball evolved from a large caliber (.50 and .60), somewhat blunt shape, into a slender, pointier, smaller caliber (~.30).

Around the same time, chemists and ballisticians from around the world were working on a replacement for black powder. These new "smokeless" propellants presented new challenges for the hard lead cast bullet. These new propellants created much higher pressures and pushed bullets to velocities not seen with black powder. The higher velocity and pressure caused lead bullets to begin to melt and deform in the bore. In 1882, Swiss Lt. Colonel Eduard Rubin invented the first copper jacketed bullet. The bullet featured a lead core and a thin, copper envelope in calibers 7.5 mm and 8 mm. This bullet became the precursor to the bullet used in the 8 mm Lebel, the first smokeless centerfire cartridge.

In the beginning of the 20th century, advances in aerodynamics led to the creation of the "spitzer," or spire point bullet. The elongated body and sharper point of the spitzer bullet were better suited to defeating wind resistance and drift and so extended the effective range of the modern bullet. Shortly after the introduction and adoption of the spitzer bullet, a French lieutenant colonel named Desaleux introduced a spitzer bullet with a boat tail. This new design further streamlined the spitzer bullet by reducing the amount of drag the bullet experienced in flight. The boat tail spitzer has remained the basic shape for rifle bullets for the major part of the 20th and 21st centuries. Small design alterations have occurred, but the basic shape remains.

Bullet Types

Necessity has led to many of the current bullet types we see today. Hunting, self-defense, war, and even sport shooting, have all contributed to the many bullet types currently in use. Each bullet type will have a specific use, while some types will be multi-purpose. The various bullet types are described below.

- **Ball** – The term "ball" is very misleading. Ball projectiles are not spherical at all; in fact, some are long and pointed (spitzer). The term *ball* applies to bullets with a round nose and meplat, jacketed or solid (monolithic). Both pistol and rifle bullets can be found in ball configurations, with rifle bullets typically being more pointed and pistol bullets being rounder. Ball ammunition is designed to be cheap and abundant, unlike hollow point, soft point, or one of the many specialty projectiles. Ball ammunition may be solid (lead, copper, or brass), or jacketed (copper/brass/steel) with a lead or other metal core. Ball ammunition can also be found in composite materials designed to be frangible.
- Because of their design, ball projectiles are more likely to perforate (put a hole through) a target (most materials) than are other bullet types. Depending on the material the bullet impacts, there is often little to no deformation of the bullet. Often, the only markings found on recovered bullets are the engravings cut by the rifling. Ball ammunition is also more likely to ricochet off hard targets than other bullet types. The military almost exclusively uses ball ammunition, which also finds extensive use with civilians.
- Ball ammunition is also better suited for use in semi-automatic firearms. In fact, many semi-auto firearms are designed specifically for exclusive use with ball bullets. The round nose makes the perfect shape for use in magazines or to move across the feed ramp and into the chamber. The smooth nose design does not feature any edges that may hang up against the magazine or firearm, making ball bullets more reliable than other bullet shapes.

Figure 2: Various FMJ, TMJ and CMJ projectiles.

- **Full Metal Jacket (FMJ)/Total Metal Jacket (TMJ)/Complete Metal Jacket (CMJ) –** The full metal, total metal, or complete metal jacketed bullet is a variation of the ball round. The terms FMJ, TMJ, and CMJ are used to describe ball bullets, which are jacketed or covered. The FMJ utilizes a jacket that encompasses everything but the base of the bullet, while a TMJ covers the bullet completely. CMJ bullets do not technically utilize a jacket; rather the solid, swaged core is coated (electroplated) with a very thin layer of copper. There are quite a few benefits of jacketed or covered ball ammunition. A jacketed bullet can be fired at higher velocities than its non-jacketed counterpart and will experience less deformation upon impact of certain targets than its non-jacketed counterparts (the CMJ is the exception). Jacketed and coated bullets are more popular than non-jacketed solid bullets. The typical FMJ/TMJ/CMJ bullet features a copper/brass envelope and a lead core. Sometimes, other soft metals, like zinc and tin, may be used for core materials.
- **Hollow Point –** The hollow point bullet is appropriately named because of the large cavity in the nose of the bullet. The hollow point bullet is designed to limit penetration and prevent perforation. When a hollow point bullet contacts a soft target (animal or human), the hydraulic pressure created inside the cavity forces the material surrounding it outward, forcing the mouth of the opening to expand and roll over itself. As the bullet expands as it moves through the target, the increased surface area will dramatically slow the projectile. The bullet's expansion is what prevents it from perforating the target and possibly damaging or injuring (or worse) something behind it. When a hollow point bullet impacts any other material, it may fail to expand, or will distort unexpectedly. Some materials may clog the cavity of the bullet and prevent it from expanding because of the lack of hydraulic force. The traditional hollow point bullet is manufactured with a copper/brass jacket and a lead core. Modern hollow point bullets are moving toward solid copper/brass construction.

Figure 3: Various hollow point projectiles.

Figure 4: Various soft point projectiles.

The hollow point bullet may be solid or jacketed. When solid hollow points expand (under hydraulic pressure) and the mouth rolls over, the recovered bullet may look like a mushroom. This is where the term "mushrooming" comes from. Jacketed hollow points typically feature a jacket that extends up to the mouth of the cavity, or slightly short of it but never inside of it. The jacket may be solid, or it may be scored or pre-stressed so that upon impact, the jacket will expand, split, and form "petals." These petals are devastating to soft tissue and create enough drag to stop the projectile inside the target.

The hollow point bullet is used almost exclusively by law enforcement and civilians for self-defense. The use of hollow point bullets by the military is prohibited by The Hague Convention. The hollow point's design makes it the perfect choice when over-penetration or perforation is a concern, especially with hunting and self-defense. Because of the increase in quality control and cost of manufacturing, hollow point ammunition is often two to three times more expensive than ball ammunition.

- **Soft Point –** The soft point is so named because of the exposed, malleable core that protrudes from the jacket at the nose of the bullet. With soft point bullets, the jacket (copper) will typically cover the base completely and extend upward, stopping just short of the tip. The core (lead) of the bullet will fill the jacket completely and protrude upward from the opening in the front of the jacket. The exposed core, protruding from the jacket, will form a semi-pointed/round/flat tip. The soft tip is designed to promote deformation and expansion. When the bullet impacts the target, the first point to hit is the soft tip. The tip will begin to deform and push back into the jacket, forcing the nose of the jacket to expand and deform. The soft point bullet is not as finicky as the hollow point bullet and will expand through a variety of conditions.

  The soft point is designed to be more aerodynamic than a hollow point bullet and experiences greater expansion and deformation than a ball bullet. The soft point bullet will also penetrate deeper than a traditional hollow point. The rate

of expansion is dependent on the alloy of the core, the velocity of the bullet upon impact, and the material that is being impacted. If the material is too soft, the soft point may not expand and will perforate the target similar to a round nose bullet.

There is a variation of the soft point bullet known as the "partition." The partition features two distinct sections of lead separated by a unique jacket. The nose is designed like a typical soft point while the lead in the nose is partitioned from the lead in the body of the bullet. This allows the nose of the bullet to expand like a traditional soft point, while the body remains intact and retains some of its original mass.

- **Match –** Match bullets are manufactured to a much higher tolerance than other bullets. The core of the match bullet is much more consistent in the mixture of its alloying materials and the bullets are almost always swaged for the most uniform shape and weight. The jackets are also drawn with greater precision to ensure the most uniform wall thickness and concentricity to the core. The machines used to manufacture match bullets are more precise and consistent than machines used to manufacture bulk ammunition. The quality control process involved in manufacturing match bullets is also more meticulous, sometimes featuring human interaction during every step of the process. In some cases, match bullets are also weighed, measured, and sorted for the utmost consistency between batches.

  Match bullets are not limited to a particular style or type, and can be found in both pistol and rifle bullets, ball, hollow point, open tipped, tipped and many other styles. Match bullets will typically utilize many features to make the bullet more aerodynamic, including various types of tips, long ogives, and boat tails.

  Match bullets are only the beginning of match ammunition. As is often the case, propellant and primer are all of a higher quality and manufactured more consistently. Match bullets are utilized primarily by competition and target shooters.

- **Very Low Drag (VLD) –** Very low drag bullets are the current pinnacle of aerodynamic projectile design. They are designed to be extremely streamlined to overcome disruption from outside forces. The name *very low drag* indicates that the projectile will experience less air resistance than other projectiles of the same size and weight, with a less aerodynamic form. This means the VLD bullet can fly farther, maintain its velocity over a greater distance, and resist wind and atmospheric conditions better than any other projectile type.

  The typical VLD projectile is a jacketed (lead core), open tip (not hollow point), boat tail design. The VLD bullet tends to be very long and heavy for a bullet of its caliber, with a longer tapered or rebated boat tail, a short bearing surface, and a very long secant or hybrid ogive nose. The open tip design is used to shift the projectile's weight rearward, increasing its stability. The VLD projectile will be built to match standards and may sometimes feature a tip to further increase aerodynamics. The VLD is used primarily by long-range competition shooters but can also be manufactured as a hollow point used for long-range hunting.

- **Tipped –** Tipped bullets utilize a specialized tip of varying materials for different purposes. The tip may be made from hard polymer, rubber, aluminum, steel, or titanium. Polymer tipped bullets serve many purposes, including making flat or hollow point bullets more aerodynamic, assisting hollow point bullets in expansion, increasing the feeding reliability of hollow points, and making

Figure 5: Various polymer tipped projectiles.

pointed (spitzer) bullets safe to load into lever-actions.

The polymer tip turns flat and hollow point bullets into more of a spitzer shape, making them less susceptible to drag, allowing them to move faster and farther. The polymer tip may also aid in (more consistent) expansion by acting as a wedge, driving into a cavity, and forcing the core and jacket outward. It also makes the bullet expand more consistently through a variety of materials (wood, drywall, sheet metal, glass, heavy clothing) rather than just expanding from hydraulic pressure.

Some hollow point bullets utilize a polymer tip with a round nose that aids in feeding with semi-automatic pistols. Because many semi-auto pistols are designed to primarily use ball ammunition, using hollow point bullets may cause malfunctions in the feeding cycle of operations. The ball tip eases the bullet's transition up the feed ramp and into the chamber. The ball also acts as a wedge, aiding in more consistent expansion. With bullets intended for lever-actions, the polymer tip allows the use of spitzer-style bullets without the risk of unintentional discharge. If a traditional spitzer bullet were used in a tubular magazine, a large enough shock (recoil) may cause the tip of one cartridge to strike the primer of the cartridge in front of it, setting off a dangerous chain reaction. Rubber tips are generally used with pistol bullets to aid with expansion.

Steel tips can be used to increase the penetration capabilities of a certain projectile. The steel tip can be used for large or dangerous game with thick hides and heavy bones. Aluminum and titanium tips are generally used for their aerodynamic advantage, while also shifting the bullet's weight, making it more stable. Aluminum and titanium tips are also used to aid in expansion, while titanium tips can also be utilized as a visual reference of impact. The titanium tip will create a bright flash or light and spark when contacting a hard target. Titanium and steel tips are also utilized with bullets designed to penetrate armor.

- **Bonded** – The bonded bullet is designed to prevent jacket/core separation. Jacket separation can be counterproductive to

the bullet's performance, as it can cause the core to fragment and limit penetration where it is needed (vital organs). The bonded bullet utilizes a mechanic bond to secure the jacket to the core. This comes in the form of cannelures or internal rings of material to secure the core inside the jacket. Bonding typically occurs around halfway down the bullet to allow the nose of the bullet to expand, and the body of the bullet to remain unchanged. Bonded bullets can be found in hollow points, soft points, and tipped. The bonded bullet is a preferred choice of the hunter because it allows the bullet to expand, causing greater tissue damage, while maintaining as much mass as possible so that it can penetrate as deeply as possible.

- **Wadcutter** – The wadcutter bullet is designed primarily for use in target and bullseye competition. The basic wadcutter (full wadcutter) bullet features a completely flat nose. From the bearing surface, the shoulder turns 90° to the face. The sharp shoulder is designed to "punch" a perfectly round hole in a piece of paper. The idea behind the wadcutter design is that there is no way to dispute the score on the target because the holes are cut so precisely. Other bullet designs typically tear through paper, leaving torn or serrated holes.

  Because of the shape of wadcutter bullets, they are typically limited to subsonic velocities and distances of 25 yd. or less. Wadcutter bullets will also typically feature solid construction. The subsonic velocities will not distort solid, soft (lead) bullets and will not melt or foul the bore as if they were moving at supersonic speeds. There are jacketed wadcutter bullets that feature a jacket that extends half to three-quarters of the way up the bearing surface. These rounds can be fired at supersonic speeds and do not foul the bore as much as solid wadcutters. While the typical wadcutter design features a completely flat face, there are variants that feature small differences. Wadcutter bullet designs include target (small ring groove on the face of the bullet), hollow base, hollow point, beveled base (small bevel on the base that aids in loading the cartridge), and double-ended (a bevel on each end).

  The wadcutter bullet is also not suited for use in anything other than revolvers. The shape of the bullet creates a feeding nightmare for magazine-fed, semi-automatic pistols. When the wadcutter is used in a revolver's cylinder, there are no issues, as the cartridges do not undergo a "feeding cycle." With the typical wadcutter cartridge, the bullet is set back in the case so that the face of the bullet is flush with the case mouth. Some cartridges feature a bullet that is seated farther out.

  Because of the shape of the bullet and the fact that they are typically "heavy" for a bullet of a specific caliber (there are no tapers, so there is more material and more mass), wadcutter bullets are sometimes used for hunting at close distances (loaded to supersonic velocities within ~50 yd.). The increased surface area on the nose of a wadcutter will impact the target harder than a similarly designed bullet with a spitzer point, which is more likely to perforate the target. The wadcutter bullet is more likely to deliver all of its energy to a target, rather than carrying its energy through the target. This is why the wadcutter bullet is also sometimes used for self-defense. Traditional wadcutter bullets are almost exclusively used in revolvers.

Semi-Wadcutter– The semi-wadcutter (SWC) is similar to the wadcutter in purpose but differs dramatically in design. The wadcutter bullet utilizes the sharp shoulder of the traditional wadcutter but features a nose similar to a ball round. The semi-wadcutter is designed to cut precise holes like the traditional wadcutter, but features enhanced aerodynamics like a ball round. From the shoulder, the nose of the bullet is rebated (reduced diameter). The shape of the nose will vary greatly depending on the bullet design. The various semi-wadcutter designs include button nose, conical, Keith/truncated, and round nose.

The button nose semi-wadcutter features a small button-shaped nose that projects from the face of the wadcutter. The conical wadcutter features a sharp cone-shaped nose. The Keith or truncated conical wadcutter features a cone-shaped protrusion with its nose cut off. The nose of the truncated wadcutter is flat but there are also some hollow point versions. The round nose wadcutter features a nose similar to a ball round. The SWC may be fully or partially jacketed or may utilize a gas check.

A benefit of the SWC over the traditional wadcutter is the enhanced reliability when feeding through semi-auto pistols. The nose on the SWC (specifically truncated and round) is designed to improve the bullet's ability to travel through the breech (through the magazine, up the feed ramp, and into the chamber). The SWC also benefits from the aerodynamic advantage in the form of increased effective range (100+ yd.). SWC bullets may be fired at both subsonic and supersonic velocities. The semi-wadcutter is used in both revolvers and semi-automatic pistols.

Flat Nose/Truncated – The flat nose or truncated bullet features a nose that is flat. Unlike the wadcutter or SWC, the flat nose/truncated bullet does not feature a sharp shoulder or rebated nose. The flat nose bullet serves the same purpose as the wadcutter and SWC bullet while displaying greater aerodynamics and enhanced reliability when feeding in semi-auto pistols. The main difference between the flat nose and truncated bullet is the shape of their ogives. The flat nose bullet features an ogive similar to a round nose bullet: an arc that extends from the bearing surface to the meplat. Unlike the round nose bullet, the meplat of the flat nose bullet is flat with a very sharp shoulder from the ogive to the meplat. The ogive on the truncated bullet is flat. From the bearing surface, the nose of the bullet is shaped like a cone with its tip cut off. The flat nose and truncated bullet may be solid or jacketed/semi-jacketed. Flat nose and truncated bullets are used primarily in semi-automatic pistols and some rifles.

- **Specialty Bullets** – Modern materials, design, and manufacturing have led to an array of specialty bullets — all meant to be the next "big thing." Computer aided drafting (CAD), finite element analysis (FEI), and fluid dynamic software have made it possible to design and test a bullet's performance without ever firing a single shot. Advanced technology has allowed designers to create bullets that take advantage of physics to inflict the greatest possible tissue damage, penetrate deeper, or defeat barriers and armor. Much of the specialty projectile market may be regarded as "fad" or novelty, but some designs or concepts take hold or lay the groundwork for what's to come.

These specialty designs take advantage of known physical forces from other sciences, such as hypervelocity, supercavitation, centrifugal force, and the Venturi effect. Other specialty projectiles take advantage of material science and design to create bullets that expand to diameters much larger than any hollow point, while others are designed to fracture, creating multiple wound channels and increasing the chances of incapacitating tissue damage.

Hypervelocity bullets are typically light for caliber, which allows them to reach velocities far beyond other bullets of the same caliber, typically beyond 3,000 fps. The increase in velocity is designed to increase the bullet's capability to create hydrostatic shock. Hydrostatic shock is a condition where light-weight, high velocity projectiles create a pressure wave in soft tissue that travels throughout the medium and causes remote damage. The hypervelocity bullet typically features solid construction, turned from solid brass, copper, or aluminum.

Bullets designed to create a supercavitation effect feature a nose that creates an air bubble around the projectile to limit drag through tissue and increase its ability to penetrate. Bullets designed to take advantage of centrifugal force utilize a nose design that forces tissue outward, increasing tissue damage. Bullets that utilize a Venturi effect compress fluid and tissue ahead of the bullet and expel it outward, increasing the amount of soft tissue damage.

Expanding projectiles are similar to traditional hollow points in that they both expand, but differentiate from traditional hollow points in that they do not "mushroom." A traditional hollow point will expand upon contact with fluid or soft tissue, but the "petals" will continue to roll or fold over back toward the body of the projectile, decreasing the potential frontal area of the bullet. An expanding bullet will open up like a hollow point, but the petals will not roll back like a hollow point. The petals will remain expanded to create the greatest possible frontal area.

A variation of the expanding bullet is the fracturing bullet. The fracturing bullet performs like an expanding bullet, but once the petals have opened up to a certain angle, they will break off of the base and continue on in various directions, creating multiple wound channels. The base, which retains the most mass, will also continue along the initial wound path, typically penetrating deeper than any of the petals. The number of petals may range from 3 to 9, creating up to 10 wound channels (including the base). The fracturing bullet is a variation of the frangible bullet.

Military

Military projectiles typically consist of ball, rifle, and pistol bullets. However, militaries all around the world utilize specialty projectiles for a variety of reasons. Some of these specialty rounds are used to defeat armor (both hard and soft), identify trajectory and point of impact, or prevent penetration of hard targets. Special rounds include armor piercing (AP), tracer, and frangible.

- **Armor Piercing –** The armor piercing bullet (as its name implies), is used to perforate both soft and hard body armor and vehicle armor. Most AP bullets are constructed in a similar way to standard ball rounds, with the exception of a steel (typically hardened) or tungsten (carbide) penetrator. The typical AP round features a core consisting of a steel or tungsten spike in front of or enveloped by a lead, aluminum, or tin/bismuth core encased by a full or partial jacket. Upon impact, the core and jacket will separate from the penetrator as it continues into or through the armor. The penetrator may be shaped like a cone in the nose of the bullet or may be a spitzer shape centered in the core, or a spike (or spikes) positioned in the rear of the core. Some AP bullets utilize a hollow point design with the penetrator exposed in the cavity, while others utilize the penetrator as the tip.

  While most soft armor will stop almost all pistol calibers, they do not stand a chance against an AP pistol round or even a standard ball rifle round. Most AP is designed to defeat hard body armor and vehicle armor. A typical ball rifle round will fragment upon impacting hard armor, while an AP rifle round will often punch right through, leaving a hole that looks like it was laser cut. AP bullets are found in use with pistols and rifles, but there are also penetrator slugs for use in shotguns.

- **Tracer –** Tracer bullets are used to identify trajectories when shooting at night. They produce a bright flash that creates a trail behind the bullet. Tracers are primarily used with machine guns and mini guns where the firing rate is high and aiming is often accomplished by watching point of impact. In this application, tracers are often loaded every third to tenth

Figure 6: Various AP projectiles.

round. When fired, the tracer will provide a visual reference of the approximation of impact of the shot stream. When discharging at a high enough rate, it may appear as though the individual tracers are a continuous stream.

Upon discharge, as the propellant ignites inside of the case, it will also ignite chemicals compressed in the base of the bullet. The bullet often features a deep cup or hollow base but remains a primarily jacketed ball design. The color of the tracer will depend on the chemicals used, which are typically magnesium, phosphorus, and another chemical that burns a specific color. The most popular tracer colors are red (from strontium nitrate in the compound) and green (from barium nitrate in the compound), but other colors can be found.

The benefit of the tracer round is also its downfall. The bright light of the tracer round can be seen from every angle. While the tracer is providing the shooter a visual reference, it is also providing the enemy with the shooter's position.

The tracer round can also be used for training purposes. The tracer can be used to help a new shooter understand trajectory and teach point of aim and point of impact at various distances. The tracer round can also be used to show how ricochet affects the bullet's trajectory.

Although tracer rounds are available for civilian use in most states, the use of the tracer round can be dangerous in irresponsible hands. Many fires have been created by tracers fired into environments that may catch fire. Tracers should not be fired into dry grass or dead trees, and are banned for use in most indoor ranges.

- **Frangible** – The frangible projectile is designed as a training round to prevent ricochet or shrapnel and is designed to disintegrate or crumble when impacting

Figure 7: Firing tracer projectiles.

Figure 8: Various frangible projectiles.

a hard target. The frangible is constructed from powdered metal (typically copper) that is either compressed or compressed and sintered. Sintering brings the individual grains of metal powder to a temperature just short of melting. This creates a (weak) bond between the grains. The frangible may also be constructed from metal powder that is mixed with either a glue or polymer and molded. When impacting a hard target, the individual grains or small chunks will break apart, preventing penetration, perforation, or ricochet.

The frangible is used inside of "shoot houses" when practicing tactics in confined spaces. It allows the shooter to train in a simulated house without fear of shooting into another room. Frangible rounds are also used for shooting at close-range steel targets, which has become a fairly new practice in modern tactical training.

One major issue with frangible bullets is there is a chance with compressed, non-sintered rounds that they can break up in the bore and become jammed. Newer designs utilize a solid jacket over a compressed metal core to help prevent breakup in the bore. The jacket does make the frangible perform similar to a ball round on soft targets but will still break up when impacting a hard target. This makes some frangible rounds a candidate for use as a home or self-defense round. Frangible bullets (projectiles) can be found in pistol, rifle, and shotgun cartridges.

Shotgun Projectiles

Shotgun projectiles can vary more than any other projectile type, but there are three major variances: slugs, buckshot, and birdshot. Slugs are similar to bullets, with one major difference: they are designed to work in a smoothbore shotgun. Buckshot and birdshot consist of small balls of varying sizes. Because of their smoothbore design, shotguns are also capable of firing many other objects outside of their standard load, including less lethal, explosive, and armor piercing projectiles. The various projectiles that can be fired through a smoothbore shotgun make it the most versatile firearm ever. Shotgun projectiles are used for everything from hunting and self-defense to sport/competition and law enforcement/military use. To understand the capabilities of shotgun ammunition, in many places in Africa, the shotgun is known as the "poor man's elephant gun," although it would not be the preferred method (or the smartest).

Shotgun ammunition is not expressed in caliber or bore size like pistol and rifle cartridges; it is expressed in the gauge of the bore. Gauge is a measurement of the number of bore diameter lead balls that can be made from one pound of lead, which has nothing to do with the projectiles used. Shotgun projectiles are measured by the size of a single pellet and the total weight of all the projectiles in the case. Weight is almost always expressed in ounces.

- **Slug –** The slug is like a round nose bullet that is used in smoothbore shotguns. Unlike the bullet, the slug is typically the same size as the bore or slightly smaller (~.001 in. – .0005 in.). Because shotgun loads are typically very low pressure (~11,000 psi) and the wad/gas seal obturates to seal the bore, the slug does not need to expand (but may slightly). Also, unlike traditional round nose bullets, the slug will feature hollow construction, centering most of its mass toward the nose of the slug. There are slugs that are designed for use with smoothbores, chokes, and rifled bores and the slug manufacturer will often recommend the barrel or choke that should be used. The primary use for slugs is hunting at short ranges, where the use of rifles is not allowed. Some slug designs are also meant for self-defense.

There are several different slug designs, but they can all be grouped into two main categories: full bore and sabot. Full bore slugs are appropriately named because the diameter of their bearing surface is the same as the bore. Of all of the full-bore slug variances, the Brenneke and Foster slugs are the most popular.

The Brenneke slug is the original modern shotgun slug. Before the Brenneke slug, smoothbore shotguns fired cylinder diameter round balls. The need arose for a more accurate, stable projectile. Introduced in 1898, the Brenneke slug was the first projectile with a more traditional bullet shape and was used in smoothbore shotguns. The original Brenneke design features solid construction, "fins" around the circumference of the bearing surface, and a paper/fiber wad that is attached to the base of the slug.

The solid design of the Brenneke slug does not provide much stabilization and the fins do not impart very much rotation as the slug moves through the bore. From the bearing surface to the nose of the slug there is a sharp (~90°) shoulder that transitions to a short, rebated round nose similar to a SWC. The wad is attached to the base to shift the weight of the slug forward, increasing its stabilization in flight. If there is any disturbance

in flight, the air resistance around the projectile will act upon the lighter tail and "push" it in line with the slug's trajectory. The wad also serves to seal the bore upon discharge. The fins are designed to reduce the amount of bearing surface, reducing friction and increasing velocity. In flight, air resistance does act upon the fins, imparting a very slow rotation on the projectile. The Brenneke slug is used in smoothbore shotguns and with most choke types. The Brenneke slug has an effective range of about 75 yd.

Foster slugs feature some of the characteristics of the Brenneke slug but are a newer, improved design. The Foster slug features more of a ball bullet shape, with a round nose that extends from the bearing surface and tangent ogive. The bearing surface of a Foster slug is "rifled" and the base is hollow. The design of the Foster slug (with its hollow base) pushes all of the mass to the front of the bullet, eliminating the need for the wad base. Once a Foster slug leaves the barrel, the wad quickly falls off from air resistance. The Foster slug may or may not feature grooves along its bearing surface. Although the rifling is only designed to reduce friction by removing surface area from the body of the slug, the rifling will impart a small amount of rotation on the slug, providing slightly more stability than a non-rifled slug. The Foster slug is used in smoothbore shotguns and with some choke types, and has an effective range of about 75 – 100 yd.

Sabot slugs differ greatly from full bore slugs. Sabot slugs are more similar to a rifle bullet than a pistol bullet. The sabot slug utilizes a jacket that acts as a vehicle for the slug inside the bore. The sabot is similar to the combination wad/cup, except the walls of the "cup" are much thicker. The thicker walls on the sabot require a bullet that is a much smaller diameter than the bore. Twelve-gauge Brenneke and Foster slugs typically measure around .729 in. – .730 in. (12-gauge bore diameter is around .729 in. – .730 in.), while a 12-gauge sabot slug measures between ~.450 in. and .630 in.

The sabot slug is designed for use exclusively with shotguns that utilize a rifled barrel. During discharge, the sabot (not the bullet) will engage the rifling. As the sabot travels through the bore, the rifling will impart rotation on the sabot, which in turn imparts rotation on the bullet. Upon exiting the muzzle, the sabot will fall away due to air resistance while the bullet will continue ahead, stable from the rotation.

The sabot slug can be found in a variety of styles. Because the sabot protects the bore from the projectile, sabot slugs can be found with solid construction (with a variety of material), jacketed, hollow point, and tipped, and may be constructed from plastic or paper. The sabot slug is designed for use only with rifled barrels. When used in smoothbore shotguns, they do not receive the required stabilization, and as a result, accuracy suffers. The sabot slug has an effective range of 200+ yd.

Wad slugs are similar to the sabot slug with the exception that the slug itself is more like a smooth (non-rifled) Foster. The name suggests that a wad slug is similar to a Brenneke slug with the wad attached to the base, but the wad slug utilizes the combination wad/cup. In fact, standard buckshot/birdshot cups can be used. The slug itself features a deep hollow base that is reinforced by a rib that runs the diameter of the bottom of the cavity in the base. The rib prevents the slug from expanding too much and

creating unnecessary strain on the wad during discharge. The wad slug also features more of a ball nose. The diameter of the wad slug is also much closer to the bore than a sabot slug, usually measuring around .690 in. for a .729 in. 12-gauge barrel.

The wad slug is designed for use with smoothbore shotguns but can also be used in rifled barrels. The rifled barrel will impart rotation onto the wad, but because its wall thickness is much thinner than a sabot slug, the wad may become damaged. The wad slug makes reloading slugs similar as it utilizes a standard wad/cup and can be used with various crimps. The wad slug has an effective range of about 75 yd.

Plumbata slugs are similar to Foster-style slugs, but function similar to a Brenneke. The plumbata slug is typically rifled and hollow like a Foster slug but utilizes a wad that fits inside the hollow base. Working on a similar principle to the Brenneke slug, the plumbata slug utilizes a lightweight wad as a tail to help stabilize it in flight. The plumbata's wad features a wad/gas seal for its base, followed by a buffer zone, and finally a nose that fits inside the slug's base. When exiting the muzzle, the wad does not fall away from the slug but continues stabilizing its flight. It is not until impact that the wad separates from the slug.

There is a variance of the plumbata that features a sabot/wad combination. The sabot is designed to break away from the slug, leaving the wad attached to its base. The sabot/plumbata is designed for use in rifled barrels and the plumbata slug has an effective range of about 75 – 100 yd.

Shot

Shot is a term used to describe shotgun projectiles that consist of a cluster of (sometimes very small) spheres. Shot may range in size from very tiny balls to large balls the size of a 9 mm bullet. Shot size is expressed with numbers and letters: the larger the number, the smaller the shot pellet. A #12 pellet of birdshot measures around .05 in., while a 000 pellet of buckshot measures around .36 in. As shot size increases, fewer pellets can be loaded into the hull. In a 1 oz. load, ~2,000 #12 pellets will be loaded, while only 6 000 pellets will fit. Because of the wide range of sizes and loads of shot, it is one of the most versatile projectiles available.

Shot can be divided into two basic categories: bird and buck. As the name implies, bird shot is typically used for hunting birds, while buckshot is used for hunting deer and other game. Shot can also vary in the alloy of its composition. Softer shot or "chilled" shot features a higher lead content than "magnum" shot that features a higher antimony (an alloying metal used to make shot harder) composition. Some types of shot (both bird and buck) may be plated (not jacketed) with a harder metal. Because of the range in size of shot, there is typically a size for any type of game that may be encountered. Shot is also used for competition, self-defense, law enforcement, and military use.

BIRDSHOT

Of the types of shot, birdshot utilizes the smallest sized pellets. Birdshot sizes run from #12 (.05 in.) to F (.22 in.). Because of its small size, birdshot is best suited for hunting small birds, snakes, small mammals, and pests. Birdshot in sizes 12, 11, and 10 are referred to as snake/pest/dust shot because of its extensive use on nuisance animals. As shot size increases, the size of the animal that can be humanely dispatched increases. Shot sizes #9 – #7 are used for most bird

hunting and some small game: doves, pigeons, grouse, quail, partridge, rabbits. Sizes #9 – #7 are also used for sporting purposes: trap, skeet, and sporting clays. Sizes #6 – #4 are best suited for larger birds such as turkey. Sizes #3 – T are used for water fowl, such as ducks and geese, and are also suited for many varmints, including coyotes, fox, cougar, and bobcats. Pest shot has an effective range of about 10 yd. (max), while medium sized shot is around 40 yd. and sizes #3 – T can reach 50 – 60 yd.

Birdshot is also perfectly suited for home defense. One of the greatest considerations when choosing home defense ammunition (or any defensive ammo) is over-penetration. Walls inside of a home typically consist of wood framing, sheet rock, and some insulation. There may also be some wire and plumbing. Most rifle and handgun bullets will perforate through at least one complete wall, endangering anyone in the other room. Slugs and buckshot will produce the same results. Many of those same cartridges will perforate several walls, including exterior walls (with the added layers from siding, stucco, or brick) and continue into another dwelling.

The small size and low mass of birdshot makes it perfect for use inside of the home. Shot in sizes #7.5, #7, and #6 are the best balance of shot size and weight (~1.5 grains per pellet), and pellet count. Shot size #7.5 will typically only perforate a single layer drywall, becoming stuck in the second layer on the opposite side. The shot may perforate the second wall but will not typically have enough energy to cause life threatening injury. If the shot were to perforate one complete wall, it would not make it through a second. The energy and penetration from the shot may not be enough to completely incapacitate an intruder, but the tradeoff is the safety of other family and friends inside the home (and anyone outside of the home).

BUCKSHOT

Buckshot is much larger than birdshot, ranging from #4 (.24 in.) to 000 (pronounced triple aught) (.36 in.). Because of its larger size, buckshot is suited for small and large game. Buckshot is used to harvest everything from varmints to elk. Shot sizes #4 – #3 are useful for large birds, such as geese, and small to medium varmints. With #2 and #1 buck, you begin to get into medium game territory, pronghorn, and deer within ~40 yd. Buckshot in sizes 0 (aught), 00 (double aught), and 000 (triple aught) is used for medium to large game. Single aught is good for medium game such as pronghorn, ram, and coyote. Between double aught and triple aught you can harvest several types of big game, including deer, caribou, and most bears (black, grizzly, polar, and brown).

Figure 9: Various shotgun projectiles.

Buckshot is not a responsible choice for home or self-defense (except for some of the smaller calibers) because of its larger size, pellet count, mass, and energy. Most buckshot will perforate several walls inside a home and continue outside. Even if you hit your intended target, there is still risk of perforation into other rooms. Buckshot's primary purpose is hunting medium to large game and is often too powerful for most other tasks. Buckshot, typically 00 and 000, has also found extensive use with military and law enforcement.

SELF-DEFENSE SHOTSHELL PROJECTILES

Although we have established that most buckshot and slugs are not very well-suited for self- or home defense, specialty loads have been developed by mixed slugs and shot of various sizes. Some of these specialty loads may feature a few smaller (under #1) buckshot pellets, followed by a slug that is typically half of its normal weight. Other designs may use small, stacked disks (similar to a nickel) followed by larger birdshot (B and above). Others may utilize a mixture of a few smaller buck and several larger birdshot (B and above) pellets. Limiting the number of larger projectiles and increasing the number of smaller projectiles will increase the likelihood of a hit, while still providing more energy than small projectiles alone. It will also prevent the likelihood of over-penetration and perforation. The smaller birdshot will not likely penetrate more than a wall, and the smaller number of larger projectiles limits the chance of one of hitting something unexpected in another room.

Outside of the specialty rounds that are available, there is also a category of less-lethal options. These projectiles are designed to cause injury and pain, but they will not typically penetrate, let alone perforate. These less-lethal projectiles are often shaped like slugs or buckshot but are made from a very dense rubber. Upon impact, these projectiles will often bounce off of the intended target, leaving large welts and bruising. There are also "bean bag" projectiles that are filled with birdshot sized rubber pellets.

The reason these projectiles are called less-lethal and not non-lethal is there is still a chance for severe injury or worse. Less-lethal rounds are designed to be fired below the target's neck. If fired at the head, the impact may be enough to kill instead of injure. The greatest downside to less-lethal projectiles is if the target is not incapacitated and continues forward to attack. Less-lethal rounds may even be illegal to use for self-defense in some areas. Less-lethal rounds are employed mostly by law enforcement and the Department of Corrections.

Chart 1

12-Gauge Shotshell		
Size	**Diameter in Inches**	**Pellets per Ounce (Average)**
Lead Birdshot		
12	.05”	2,385
11	.06”	1,250
10	.07”	1,040
9.5	.075”	688
9	.08”	585
8.5	.085”	497
8	.09”	410
7.5	.095”	350
7	.1”	300
6	.11”	225
5	.12”	170
4	.13”	135
2	.15”	90
BB	.18”	50
Steel Birdshot		
8	.09”	577
7.5	.095”	490
7	.1”	420
6	.11”	317
5	.12”	247
4	.13”	192
3	.14”	154
2	.15”	125
1	.16”	103
B	.17”	86
BB	.18”	72
BBB	.19”	61
T	.2”	53
F	.22”	40
Buckshot		
4	.24”	22
3	.25”	19
2	.27”	15
1	.3”	11
0	.32”	9
00	.33”	8
000	.36”	6
Slug		
Foster/Brenneke	.729”	1

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